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TITLE: HYDROSTATIC MAGNETIC COMPOSITE BEARING AND SPINDLE DEVICE

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INVENTOR-INFORMATION:

NAME	COUNTRY
SUZUKI, NOBUYUKI	
YAMADA, HIROYUKI	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
NTN CORP	N/A

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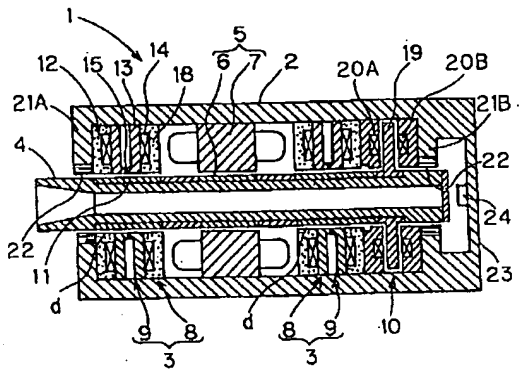
ABSTRACT:

PROBLEM TO BE SOLVED: To provide a hydrostatic magnetic composite bearing to have excellent dynamic rigidity of a hydrostatic bearing, rotation precision, and excellent static rigidity of a magnetic bearing and be formed in a compact manner and to provide a spindle device.

SOLUTION: A **hydrostatic bearing** 19 and a magnetic bearing 8 are integrally formed to form a hydrostatic magnetic composite bearing **3**. The hydrostatic magnetic composite bearing 3 and a built-in type **motor** 5 are combined together to form a **spindle** device 1. The hydrostatic magnetic composite bearing **3** is provided at the internal part of the stator core 13 of the magnetic bearing 8 with the air supply passage of the **hydrostatic bearing** 9 and an autogenous

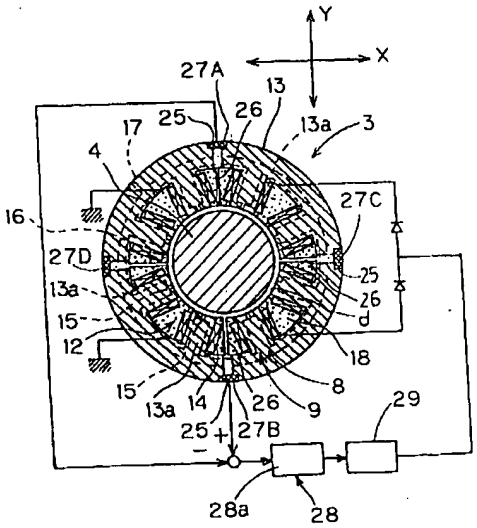
throttling 15. This constitution uses the parts of the magnetic bearing 8 are the hydrostatic bearing 9 as both and uses a hydrostatic bearing gas (d) and a magnetic gap in combination, and forms a device in a compact manner. This hydrostatic magnetic composite bearing is also applicable for an axial bearing in addition to a radial bearing.

【図1】



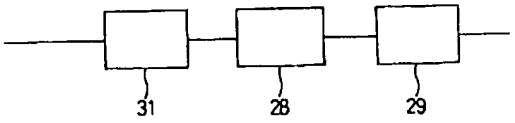
1:スピンドル装置
2:ハウジング
3:静圧磁気複合軸受
4:主軸
8:磁気軸受
9:静圧気体軸受
12:軸受ステータ
d:軸受隙間

【図2】



12:軸受ステータ
13:ステータコア
15:ノズル
27A～27D:圧力センサ
28:磁気軸受制御手段

【図6】



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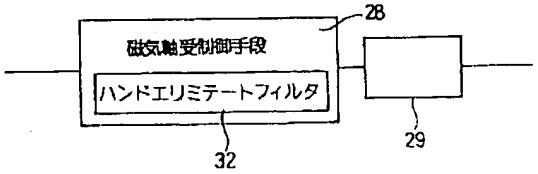

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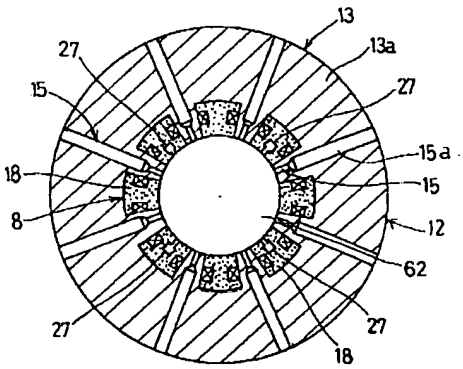

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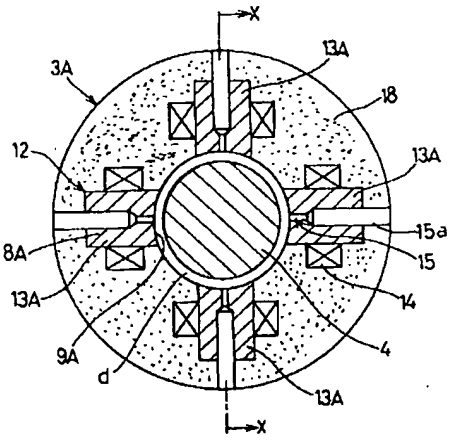

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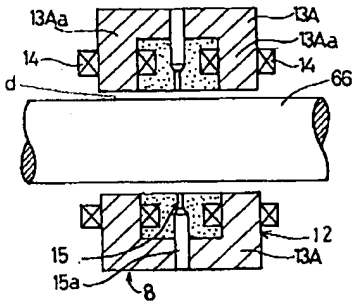

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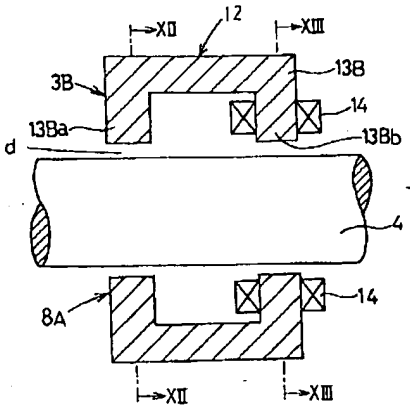

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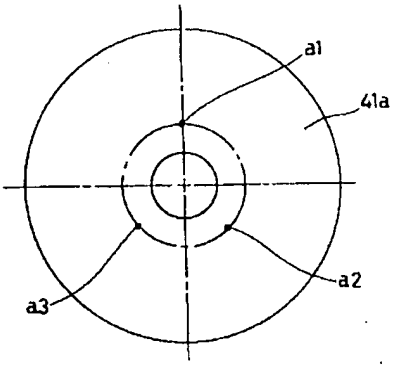

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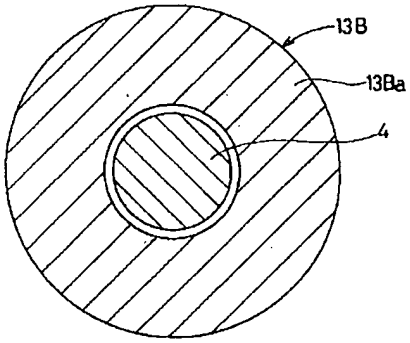

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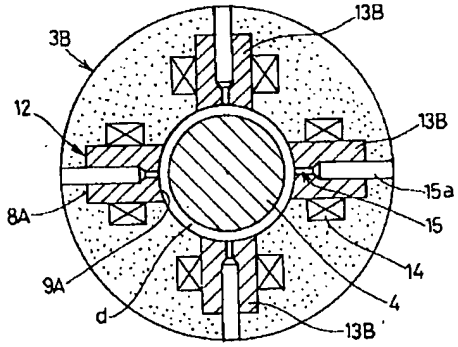

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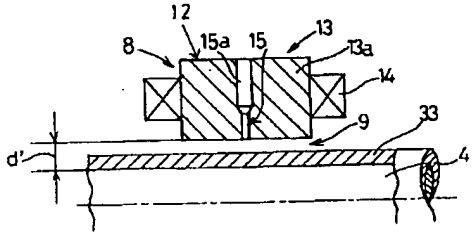

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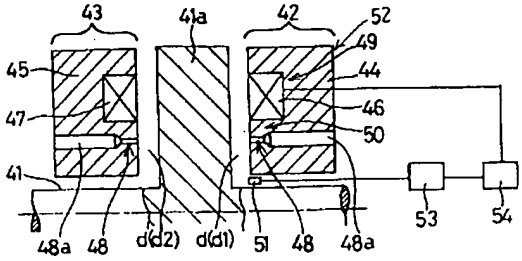

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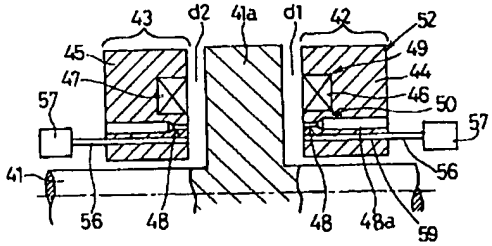

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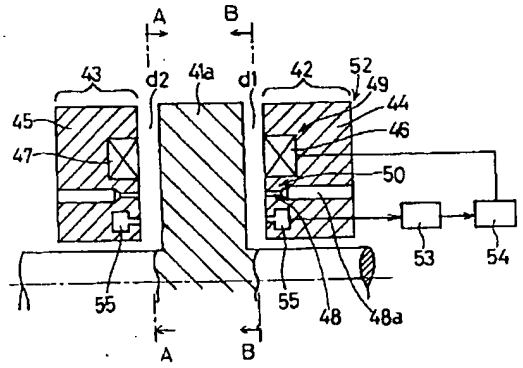

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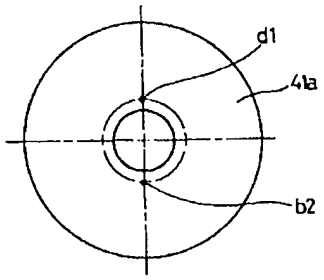

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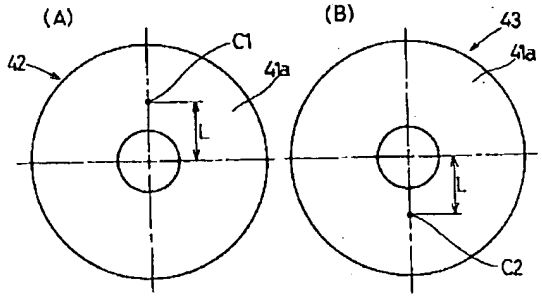

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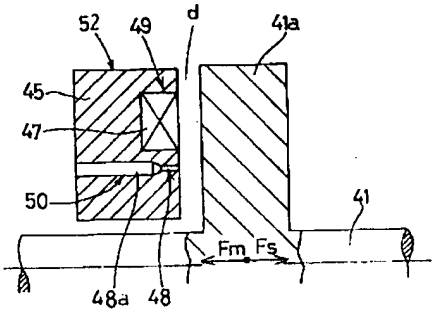

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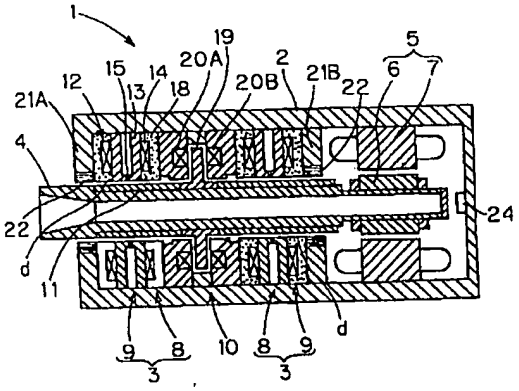

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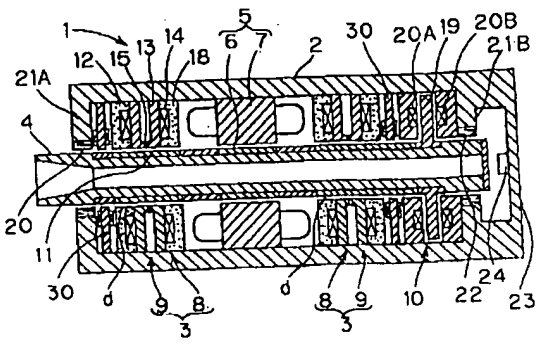
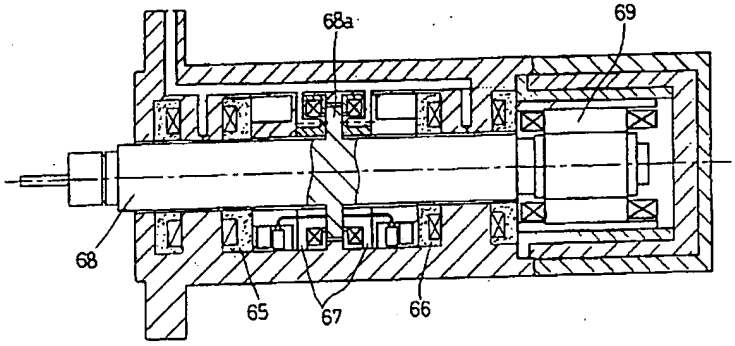
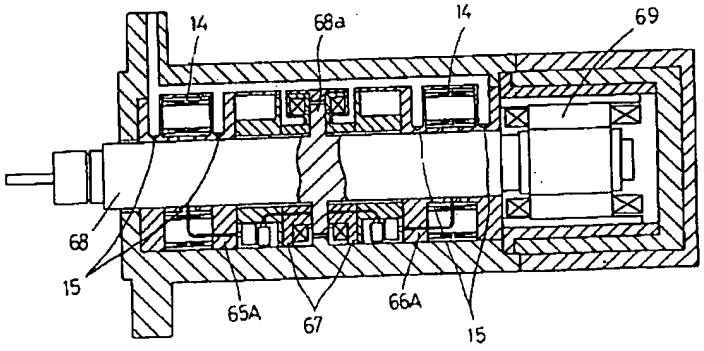


30:渦電流式変位センサ

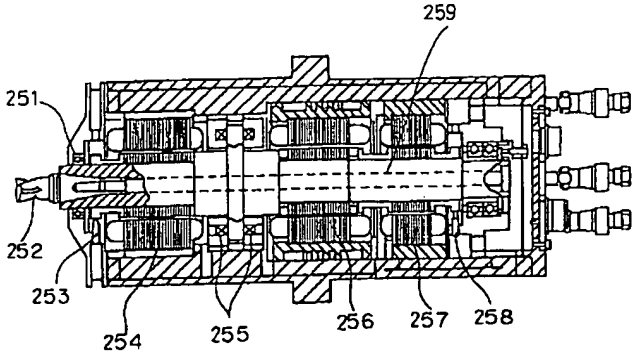
【図24】


68a
69
68
65
67
66

【図25】


14
68a
14
69
68
15
65A
67
66A
15

【図26】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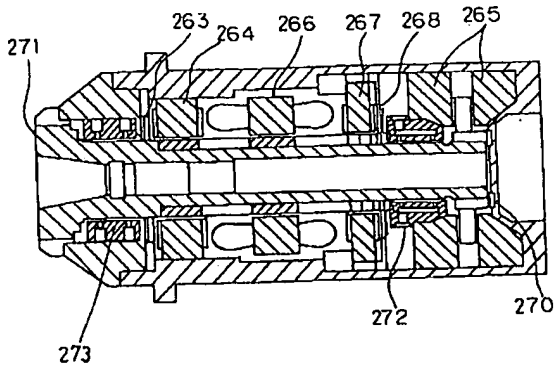
258

【図27】



CLAIMS

[Claim(s)]

[Claim 1] The ** pressure magnetism compound axle hole which formed in incore [of the electromagnet of a magnetic bearing] the iris diaphragm which supplies air to the axle hole crevice between ** pressure gas bearings.

[Claim 2] The ** pressure magnetism compound axle hole which unified the magnetic bearing and the ** pressure gas bearing so that a combination portion might arise mutually.

[Claim 3] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- the ** pressure magnetism compound axle hole which put side by side the magnetic bearing which is made to generate power and supports a rotor in a predetermined position, and the ** pressure gas bearing which has self-****** or an orifice iris diaphragm in the axle hole stator of this magnetic bearing.

[Claim 4] The ** pressure magnetism compound axle hole which is radial bearing and prepared the ** pressure gas bearing in the direction width of an axis of the whole magnetic bearing.

[Claim 5] The ** pressure magnetism compound axle hole which is radial bearing and prepared the magnetic bearing in the direction width of an axis of the whole ** pressure gas bearing.

[Claim 6] it is radial bearing -- the axle hole crevice between ** pressure gas bearings, and the rotor of a magnetic bearing and the gap between cores -- mutual -- the direction of an axis -- abbreviation -- the ** pressure magnetism compound axle hole prepared in the same position.

[Claim 7] the electromagnetism of the electromagnet core of a magnetic bearing -- preparing self-****** of a ** pressure gas bearing in a power generating side -- said electromagnetism -- the ** pressure magnetism compound axle hole according to claim 1 to 6 which set the crevice between a power generating side and a rotor to 0.1mm or less.

[Claim 8] The ** pressure magnetism compound axle hole according to claim 1 to 7 which coincided mutually the polarity of the magnetic pole which is radial bearing, puts in order and

said each embodiment for the ******** pressure magnetism compound radial bearings 65 and 66 and the ** pressure magnetism compound AKISHARU axle hole 67. Moreover, in the spindle equipment of this figure, as 2 sets of ** pressure magnetism compound radial bearings 65 and 66, as shown in drawing 25 , you may use for the both sides of the direction of a principal-axis axis of a coil 14 the ** pressure magnetism compound radial bearings 65A and 66A which have self-****** 15. The composition of others in the ** pressure magnetism compound axle hole spindle equipment of drawing 25 is the same as the spindle equipment shown in drawing 4 . In addition, in the spindle equipment of this invention, no axle holes not necessarily need to consist of ** pressure magnetism compound axle holes. the static stiffness of only the direction of thrust is raised -- required -- in a certain case, only an AKISHARU axle hole part is constituted from a ** pressure magnetism compound axle hole, and it should just constitute axle hole support of a radial direction from a ** pressure gas bearing. Moreover, when there is the necessity of raising the static stiffness of only a radial direction, the ** pressure magnetism compound radial bearing 65 may be arranged at the end of a spindle load side, and other axle hole supporters may consist of ** pressure gas bearings. Moreover, in this ** pressure magnetism compound axle hole spindle equipment, when the control gain of the magnetic bearing is lowered at the time of low-speed rotation and a principal axis becomes more than predetermined number of rotations, it is desirable to make it change said control gain to a predetermined value. A setup and change of this control gain are made with the magnetic bearing control means 28 and 53.

[0060] The starting method of the spindle equipment constituted from a **** magnetism compound axle hole is shown below. Each of these starting methods and each starting methods explained later is applicable to any spindle equipment of each of said embodiment. By this starting method, pressure fluid is first supplied to an iris diaphragm of each ** pressure magnetism compound axle holes 65-67, and a rotor is surfaced only by a ** pressure gas bearing. In the state of the surfacing, the value of a displacement sensor (or displacement measurement value by a pressure sensor) is shifted to zero, and control of a magnetic bearing is operated after that. Thus, by starting, a principal axis or a rotor can always be surfaced in the state of the balance with prudence of a ** pressure gas bearing and a principal axis, or a rotor, current cannot be vainly sent through the electromagnet coil of a magnetic bearing, and the influence by the negative rigidity of a magnetic bearing can be inhibited.

[0061] Other starting methods are shown below. Pressure fluid is first supplied to an iris diaphragm of each ** pressure magnetism compound axle hole, and a principal axis or a rotor is surfaced only by a ** pressure gas bearing. In the state of the surfacing, predetermined number of rotations is rotated, only DC ingredient of a displacement sensor output value (or displacement measurement value by a pressure sensor) is shifted to zero, and control of a magnetic bearing is operated after that. By performing such starting, not only in the balance

with a ** pressure gas bearing and a principal axis, or rotor prudence Also in consideration of the static power produced from a principal axis and the delicate unbalance of the applied force from the surrounding fluid of a rotor, a magnetic bearing can be operated by setting the state as a rotor center with rotation of a principal axis or a rotor. moreover, a principal axis and the iron generated in a principal axis and a rotor by the magnetic flux of a magnetic bearing at the time of a rotor rotation rise -- disadvantage influence can be avoided and a high velocity revolution becomes possible.

[0062] Furthermore, the different starting method is shown below. First, pressure fluid is supplied to an iris diaphragm of a ** pressure magnetism compound axle hole, and a rotor is surfaced only by a ** pressure gas bearing. In the state of the surfacing, the value of a displacement sensor (or displacement measurement value by a pressure sensor) is shifted to zero. A magnetic bearing is operated where the gain of a magnetic bearing control circuit is lowered. Then, when it becomes more than predetermined number of rotations, said control gain is changed to a predetermined value. the iron generated in a principal-axis rotor by the magnetic flux of a magnetic bearing by performing such starting at the time of a principal axis and a rotor rotation rise -- disadvantage influence can be avoided and a high velocity revolution becomes possible. Furthermore, since a magnetic bearing is operated where a gain is lowered, the principal axis of the moment of operating, and the disturbance to a rotor can control a magnetic bearing.

[0063]

[Effect of the Invention] Composition becomes compact, having the dynamic stiffness which was excellent in the ** pressure gas bearing, and the static stiffness which was excellent in the magnetic bearing, in order that each of ** pressure magnetism compound axle holes of this invention and spindle equipment may combine a ** pressure gas bearing and a magnetic bearing by a predetermined relation. When it applies to radial bearing, principal-axis length can also be shortened.

[0064] When a pressure sensor is used for a displacement measurement means to measure displacement of a rotor, while highly precise displacement detection is attained, compact axle hole composition is attained, and the axle hole center of a ** pressure gas bearing can be set up focusing on a magnetic bearing, and it becomes easy to prevent the mutual interference of both bearings. moreover, highly-precise-izing of the ** pressure gas bearing by improvement in the processability of the iris diaphragm for air supply by selection of the core of an electromagnet, or the quality of the material of a rotor, and combination, miniaturization, or iron -- the exothermic prevention by disadvantage mitigation, high velocity revolution-ization, etc. are realizable. Magnetic bearing control means Improvement in the static stiffness which is the feature of a magnetic bearing is attained without spoiling the dynamic stability which was excellent in the ** pressure gas bearing, when performing only an integral action or a

proportionality integral action and not controlling to the high frequency more than predetermined.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning the 1st embodiment of this invention.
[Drawing 2] It is the explanatory view shown combining the transverse cross section of the ** pressure magnetism compound radial bearing, and the block diagram of an axle hole control system.
[Drawing 3] It is the elements on larger scale of the said ** pressure magnetism compound radial bearing.
[Drawing 4] It is the elements on larger scale of the modification of the York portion of the said ** pressure magnetism compound radial bearing.
[Drawing 5] It is the explanatory view showing the example of current control of the said ** pressure magnetism compound radial bearing.
[Drawing 6] It is the block diagram showing the modification of a control system of the said ** pressure magnetism compound radial bearing.
[Drawing 7] It is the block diagram showing other modifications of a control system of the said ** pressure magnetism compound radial bearing.
[Drawing 8] It is the sectional view of ** pressure magnetism compound radial bearing concerning other embodiments of this invention.
[Drawing 9] It is the transverse cross section of ** pressure magnetism compound radial bearing concerning the embodiment of further others of this invention.
[Drawing 10] It is the longitudinal section.
[Drawing 11] It is the longitudinal section of ** pressure magnetism compound radial bearing concerning the embodiment of further others of this invention.
[Drawing 12] XII-XII of drawing 11 It is a line sectional view.
[Drawing 13] XII1-XII1 of drawing 11 It is a line sectional view.

[Drawing 14] It is the fragmentary sectional view of ** pressure magnetism compound radial bearing concerning the embodiment of further others of this invention.
[Drawing 15] It is the explanatory view shown combining the fragmentary sectional view of a ** pressure magnetism compound AKISHARU axle hole and the block diagram of an axle hole control system concerning the embodiment of further others of this invention.
[Drawing 16] It is the explanatory view shown combining the fragmentary sectional view of a ** pressure magnetism compound AKISHARU axle hole and the block diagram of an axle hole control system concerning the embodiment of further others of this invention.
[Drawing 17] It is the fragmentary sectional view of ** pressure magnetism compound radial bearing concerning the embodiment of further others of this invention.
[Drawing 18] It is the explanatory view of the point of measurement.
[Drawing 19] It is the explanatory view of other examples of the point of measurement.
[Drawing 20] (A) and (B) are the explanatory views of other examples of the point of measurement respectively.
[Drawing 21] It is the fragmentary sectional view of ** pressure magnetism compound radial bearing concerning the embodiment of further others of this invention.
[Drawing 22] It is the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning other embodiments of this invention.
[Drawing 23] It is the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning the embodiment of further others of this invention.
[Drawing 24] It is the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning the embodiment of further others of this invention.
[Drawing 25] It is the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning the embodiment of further others of this invention.
[Drawing 26] It is the longitudinal section of the conventional example.
[Drawing 27] It is the longitudinal section of other conventional examples.
[Explanations of letters or numerals]
1 -- ** pressure magnetism compound axle hole spindle equipment
2 -- Housing
3 -- ** pressure magnetism compound axle hole
4 -- Principal axis (rotor)
8 -- RAJIARU magnetic bearing
9 -- RAJIARU ** pressure gas bearing
10 -- Thrust magnetic bearing
12 -- Axle hole stator
13 -- Stator core
14 -- Coil

15 -- Iris diaphragm
15a -- Air supply hole
27A-27D -- Pressure sensor (displacement detection means)
28 -- Magnetic bearing control means
33 -- Coating layer
41 -- Principal axis (rotor)
41a -- Rotor
44, 45 -- Stator core
46 -- Coil
48 -- Iris diaphragm
49 -- Magnetic bearing
50 -- ** pressure gas bearing
53 -- Magnetic bearing control means
51 -- Displacement sensor
52 -- Axle hole stator
55 -- Pressure sensor
d -- Axle hole crevice

[Translation done.]

prepares three or more electromagnets which constitute a magnetic bearing in the direction of the circumference, puts in order and prepares a pair of magnetic poles of the core of each electromagnet in the direction of the axis of rotation, and is located in a line on the same circumference of each electromagnet.

[Claim 9] The ** pressure magnetism compound axle hole according to claim 8 which made [which was connected mutually] common the magnetic pole of one of the two of the core of all the electromagnets.

[Claim 10] the electromagnetism are an AKISHARU axle hole, arrange an iris diaphragm of the electromagnet of a magnetic bearing and a ** pressure gas bearing only in one side of the direction of an axis of a rotor, and according to a magnetic bearing -- the ** pressure magnetism compound axle hole according to claim 1 to 3 characterized by balancing power and the axle hole applied force by a ** pressure gas bearing, and supporting.

[Claim 11] ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor including the ** pressure magnetism compound axle hole according to claim 1 to 10 enabling free rotation.

[Claim 12] ** pressure magnetism compound axle hole spindle equipment according to claim 11 which has arranged the ** pressure magnetism compound axle hole which becomes the load side tip part of a principal axis with radial bearing.

[Claim 13] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- [magnetic bearing / which is made to generate power and supports a rotor in a predetermined position] The ** pressure gas bearing which has an iris diaphragm is put side by side to the axle hole stator of this magnetic bearing. The ** pressure magnetism compound axle hole which established a magnetic bearing control means to have used said displacement measurement means as the pressure sensor which measures the pressure of the axle hole side of a ** pressure gas bearing, and to perform magnetism control of a magnetic bearing in quest of displacement of a rotor using the measured value of this pressure sensor.

[Claim 14] The ** pressure magnetism compound axle hole according to claim 13 said whose pressure sensor is a semiconductor pressure sensor.

[Claim 15] The ** pressure magnetism compound axle hole according to claim 13 or 14 which measures the pressure difference of the ** pressure in the ** pressure gas bearing side which is radial bearing and counters the both sides of the diameter direction of a rotor with said pressure sensor, and calculated displacement of the rotor from this measured value.

[Claim 16] The ** pressure magnetism compound axle hole according to claim 13 or 14 which is an AKISHARU axle hole, measures the pressure of three or more places on the same circumference of a ** pressure gas bearing side with said pressure sensor, and calculated

displacement of the direction of AKISHARU of a rotor from these pressure measured value.
[Claim 17] The ** pressure magnetism compound axle hole according to claim 13 or 14 which is an AKISHARU axle hole, measures the pressure of two places which counters in the diameter direction on the same circumference of a ** pressure gas bearing side with said pressure sensor, and calculated displacement of the direction of AKISHARU of a rotor from these measured value.
[Claim 18] Are an AKISHARU axle hole and arrange an iris diaphragm of the electromagnet of a magnetic bearing and a ** pressure gas bearing on both sides of the direction of an axis of a rotor, and through a rotor, while counters and a ** pressure gas bearing side An arbitrary part, The ** pressure magnetism compound axle hole according to claim 13 or 14 which measures the pressure of the part which is in point symmetry to the rotor center of said arbitrary part in the ** pressure gas bearing side of another side with said pressure sensor, and calculated displacement of the direction of AKISHARU of a rotor from both measured value.
[Claim 19] The ** pressure magnetism compound axle hole according to claim 13 to 18 arranged without separating said pressure sensor from the pressure measurement part of a ** pressure gas bearing side.
[Claim 20] The ** pressure magnetism compound axle hole according to claim 13 to 18 which separated said pressure sensor from the ** pressure gas bearing side, has arranged it, and connected the ** pressure gas bearing side with said pressure sensor in both a detailed hole, a pipe or these detailed holes, and a pipe.
[Claim 21] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- [magnetic bearing / which is made to generate power and supports a rotor in a predetermined position] The ** pressure magnetism compound axle hole which put side by side the ** pressure gas bearing which has an iris diaphragm to the axle hole stator of this magnetic bearing, and uses pure material for the core of the electromagnet of a magnetic bearing.
[Claim 22] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- [magnetic bearing / which is made to generate power and supports a rotor in a predetermined position] The ** pressure magnetism compound axle hole which put side by side the ** pressure gas bearing which has an iris diaphragm to the axle hole stator of this magnetic bearing, constituted a part of core of said electromagnet from pure material, prepared the iris diaphragm of a ** pressure gas bearing in the portion of this pure material, and used the portion of others of said core as the lamination silicon steel plate.
[Claim 23] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means --

electromagnetism -- [magnetic bearing / which is made to generate power and supports a rotor in a predetermined position] The ** pressure magnetism compound axle hole which put side by side the ** pressure gas bearing which has an iris diaphragm to the axle hole stator of this magnetic bearing, used the lamination silicon steel plate for said rotor, and gave the coating layer of Ceramics Sub-Division below 1mm thickness on this lamination silicon steel plate.

[Claim 24] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- [magnetic bearing / which is made to generate power and supports a rotor in a predetermined position] The ** pressure magnetism compound axle hole which put side by side the ** pressure gas bearing which has an iris diaphragm to the axle hole stator of this magnetic bearing, used the pure material of soft magnetism for said rotor by low thermal expansion nature, and gave the coating layer of Ceramics Sub-Division below 1mm thickness on this pure material.

[Claim 25] having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- [magnetic bearing / which is made to generate power and supports a rotor in a predetermined position] The ** pressure gas bearing which has an iris diaphragm is put side by side to the axle hole stator of this magnetic bearing. It is the ** pressure magnetism compound axle hole which shall establish the magnetic bearing control means which carries out feedback control of said magnetic bearing according to the measured value of said displacement measurement means, shall not control this magnetic bearing control means only by the integral action or a proportionality integral action, and shall not control to the high frequency more than predetermined.

[Claim 26] without it sends bias current through the coil of the electromagnet of a magnetic bearing by establishing a linearization circuit in the amplifier part which processes the output of said displacement measurement means -- Control voltage - electromagnetism -- the ** pressure magnetism compound axle hole according to claim 25 which linearized the power characteristic.

[Claim 27] It is the ** pressure magnetism compound axle hole according to claim 25 or 26 which forms an insensible belt in a means to process the measured value of a displacement measurement means, and shall not control a magnetic bearing when a magnetic bearing control means is in the range of predetermined displacement.

[Claim 28] A ** pressure magnetism compound axle hole according to claim 25 to 27 is included. It is ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor enabling free rotation. ** pressure magnetism compound axle hole spindle equipment adjusts the direct-current ingredient of the output of the

displacement detection means at that time to zero, and it was made to operate the function of a magnetic bearing after that after operating the ** pressure gas bearing and carrying out non-contact surfacing of the principal axis at the time of starting of a **** magnetism compound axle hole.

[Claim 29] A ** pressure magnetism compound axle hole according to claim 25 to 27 is included. It is ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor enabling free rotation. [the state where rotated the principal axis and it became more than predetermined number of rotations or it after operating the ** pressure gas bearing and carrying out non-contact surfacing of the principal axis at the time of starting of a **** magnetism compound axle hole] ** pressure magnetism compound axle hole spindle equipment adjusts the direct-current ingredient of the output of a displacement detection means to zero, and it was made to operate the function of a magnetic bearing after that.

[Claim 30] Including a ** pressure magnetism compound axle hole according to claim 25 to 27, are ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor enabling free rotation, and it detects that the principal axis became more than predetermined number of rotations. ** pressure magnetism compound axle hole spindle equipment as which it was made to operate a band ERIMINETO filter at the control system of a magnetic bearing.

[Claim 31] A ** pressure magnetism compound axle hole according to claim 25 to 27 is included. ** pressure magnetism compound axle hole spindle equipment from which it was made to change said control gain to a predetermined value when it was ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor enabling free rotation, the control gain of the magnetic bearing was lowered at the time of low-speed rotation and a principal axis became more than predetermined number of rotations.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the ** pressure magnetism compound axle hole and spindle equipment which are used for spindle equipment equipped with the ** pressure magnetism compound axle hole which combined the ** pressure gas bearing and the magnetic bearing, and its axle hole, for example, a high-speed cutting machine etc.

[0002]

[Description of the Prior Art] Since a magnetic bearing has a big axle hole gap, its torque loss by rotation is very small, and there is the feature which can give big static stiffness by integral control. Drawing 26 is the longitudinal section showing the conventional high-speed mealing

magnetic bearing spindle equipment for aluminum material. The spindle equipment of this conventional example has the touchdown bearing 251, a tool 252, the displacement sensor 253, the RAJIARU magnetic bearing 254, the thrust magnetic bearing 255, a motor 256, the RAJIARU magnetic bearing 257, the displacement sensor 258, and a principal axis 259. this magnetic bearing spindle equipment -- maximum speed: -- it has each performance of 40,000rpm, output:15kW, and maximum cutting capability:1250cm3 / min, and excels very much as the above-mentioned use.

[0003] However, a principal axis bends magnetic bearing spindle equipment during processing, and it tends to be influenced by character frequency, therefore needs to constitute a very complicated control system. Therefore, as spindle equipment for general-purpose work machines with which the correspondence to various processing conditions is demanded, it is not suitable.

[0004] On the other hand, there is a ** pressure gas bearing other than a magnetic bearing as a non-contact axle hole. Although the **** gas bearing has [rotation accuracy] the dynamic stability excellent very highly, since it has compressibility, static stiffness and load capacity are small, and there is almost no example of application as an object for general-purpose machine tools. <BR [0005]> Then, the compound axle hole spindle equipment which combined the ** pressure gas bearing as shown in drawing 27 with a longitudinal section, and the magnetic bearing as spindle equipment for high-speed processing machines is proposed, and utilization is considered these days. The spindle equipment of this conventional example has the displacement sensor 263, the RAJIARU magnetic bearing 264, the thrust magnetic bearing 265, a motor 266, the RAJIARU magnetic bearing 267, the displacement sensor 268, the displacement sensor 270, a principal axis 271, and the ** pressure gas bearing 272,273.

[0006] However, with the compound axle hole spindle equipment of this figure, since the magnetic bearing 264,267 and the ** pressure gas bearing 272,273 are arranged side by side in the direction of an axis, a principal axis 271 becomes long, it bends and there is a problem that character frequency becomes low. Moreover, since the composition of a control system of the completely same structure as the case of the spindle equipment which applies a magnetic bearing independently is adopted, the dynamic stability of a ** pressure gas bearing is spoiled, and there is also a problem of acting as a disturbance source rather. Moreover, in order to acquire high rotation accuracy with this spindle equipment, it is required that the displacement sensor for magnetic bearings should be high precision, but as for the displacement sensor used for a magnetic bearing, magnetometric sensors, such as an eddy current sensor, are usually used, and resolution is about 1 micrometer. On the other hand, although there is an electric capacity type displacement sensor as a high precision displacement sensor, it is expensive and use is difficult. Therefore, the present condition is that the purpose of compensating a fault mutually is not fully attained, employing the feature of a ** pressure gas

bearing and a magnetic bearing efficiently.

[0007] The purpose of this invention is to offer the ** pressure magnetism compound axle hole which cancels such a technical problem, has the dynamic stiffness and high rotation accuracy which were excellent in the ** pressure gas bearing, and the static stiffness which was excellent in the magnetic bearing, and can attain miniaturization, and spindle equipment equipped with that axle hole. Other purposes of this invention are enabling it to aim at shortening of principal-axis length. The purpose of further others of this invention is to offer a ** pressure magnetism compound axle hole and spindle equipment suitable for a high velocity revolution.

[0008] The purpose of further others of this invention is making easy prevention of the mutual interference of a ** pressure gas bearing and a magnetic bearing while enabling highly precise displacement detection. highly-precise-izing of the ** pressure gas bearing according [the purpose of further others of this invention] to improvement in the processability of an iris diaphragm by selection and combination of the core of an electromagnet, or the quality of the material of a rotor, miniaturization, and iron -- it is making realizable exothermic prevention by disadvantage mitigation, high velocity revolution-ization, etc. The purpose of further others of this invention is to enable improvement in the static stiffness which is the feature of a magnetic bearing, without spoiling the dynamic stability which was excellent in the ** pressure gas bearing by the device of a control system.

[0009]

[Means for solving problem] The ** pressure magnetism compound axle hole of this invention is constituted from a predetermined relation by each combining a ** pressure gas bearing and a magnetic bearing. For this reason, it can do with the dynamic stiffness and rotation accuracy which were excellent in the ** pressure gas bearing, and the axle hole which employed the feature of both who are called the static stiffness which was excellent in the magnetic bearing efficiently. In addition, let a ** pressure gas bearing be a ** pressure air bearing, for example. Among these, a ** pressure magnetism compound axle hole according to claim 1 forms in incore [of the electromagnet of a magnetic bearing] the iris diaphragm which supplies air to the axle hole crevice between ** pressure gas bearings. A ** pressure magnetism compound axle hole according to claim 2 is unified so that a combination portion may produce a magnetic bearing and a ** pressure gas bearing mutually. A ** pressure magnetism compound axle hole according to claim 3 is preparing self-****** or an orifice iris diaphragm in the axle hole stator of a magnetic bearing, and unifies a ** pressure gas bearing and a magnetic bearing. Self-****** performs the duty of an iris diaphragm in respect of the imagination cylinder made in an air supply hole and an axle hole crevice. a magnetic bearing having a displacement measurement means to measure displacement of a rotor, and following the measured value of this displacement measurement means -- electromagnetism -- power is generated and a rotor is

supported in a predetermined position. Even if the measurement means of displacement measures displacement directly, it may measure what is measured indirectly, i.e., another measuring object convertible into said displacement as a result. These Claim 1 - the axle hole of three may be radial bearings, or may be an AKISHARU axle hole. A ** pressure magnetism compound axle hole according to claim 4 is radial bearing, and prepares a ** pressure gas bearing in the direction width of an axis of the whole magnetic bearing. A ** pressure magnetism compound axle hole according to claim 5 is radial bearing, and prepares a magnetic bearing in the direction width of an axis of the whole ** pressure gas bearing. a ** pressure magnetism compound axle hole according to claim 6 is radial bearing -- the axle hole crevice between ** pressure gas bearings, and the rotor of a magnetic bearing and the gap between cores -- mutual -- the direction of an axis -- abbreviation -- it prepares in the same position.

[0010] Like the axle hole of these Claim 1 or Claim 6, composition becomes compact by unifying a magnetic bearing and a ** pressure gas bearing compared with the case where a ** pressure gas bearing and a magnetic bearing are only arranged side by side in the direction of an axis. When it applies to radial bearing, another length portion is not needed for support by ** pressure, and support by magnetism at the principal axis used as a rotor, but it can do in the direction of an axis with a short compound axle hole, and principal-axis length can be shortened. By this, it bends, character frequency is raised, and a high velocity revolution becomes more possible. Moreover, abbreviation coincidence of the support central point of the magnetic bearing to the direction of an axis and the support central point of a ** pressure gas bearing can be carried out, and control of both bearings becomes easy. When it applies to an AKISHARU axle hole, compared with the case where a ** pressure gas bearing and a magnetic bearing are only arranged side by side to a radial direction, composition becomes compact and the path of the axle hole opposed face of a rotor can be made small. When self-****** is used for the air supply form of a **** gas bearing, the stability over a new MATIKU hammer can improve and the axle hole stability of a high frequency region, i.e., dynamic stiffness, can be raised.

[0011] in these composition -- the electromagnetism of the electromagnet core of a magnetic bearing -- preparing self-****** of a ** pressure gas bearing in a power generating side -- said electromagnetism -- it is desirable that the crevice between a power generating side and a rotor shall be 0.1mm or less. Thus, if minute self-****** is prepared in an electromagnet core, the core section of the electromagnet used only for **** of the magnetic flux of a magnetic bearing can be used effectively. Since it usually becomes the storage space of an electromagnet coil between the York portions of a core, when forming a nozzle in this part, interference with this coil must be taken into consideration, but it is preparing a nozzle in a core and the problem [coil / such] of interference is lost.

[0012] When the axle hole of these composition is applied to radial bearing, three or more electromagnets which constitute a magnetic bearing may be put in order and prepared in the direction of the circumference, and the polarity of the magnetic pole located in a line in the direction of the axis of rotation on ******** and the same circumference of each electromagnet in a pair of magnetic poles of the core of each electromagnet may be coincided mutually. The core of each electromagnet is prepared so that it may assume horseshoe shape, for example. Thus, with constituting the core of an electromagnet, hysteresis loss and eddy current loss which are generated with the rotor of a magnetic bearing are mitigable with rotation of a rotor. By these losses being reduced, generation of heat of a rotor is controlled, reduction of the axle hole crevice between the ** pressure gas bearings by the thermal expansion of a rotor can be suppressed to the minimum, and the performance of the stable ** pressure gas bearing can be obtained. Thus, in the composition which puts a magnetic pole in order in the direction of the axis of rotation, it is good also as a common thing mutually connected in magnetic pole of one of the two in the core of all the electromagnets. Thus, with constituting a core, while being able to decrease the processing man day of an electromagnet, **** in the rotor of the magnetic bearing generated with rotation of a rotor can be reduced further, and it can respond to a high velocity revolution more.

[0013] In Claim 1 of this invention - the ** pressure magnetism compound axle hole of Claim 3 when it is considered as an AKISHARU axle hole the electromagnetism arrange an iris diaphragm of the electromagnet of a magnetic bearing and a ** pressure gas bearing only in one side of the direction of an axis of a rotor, and according to a magnetic bearing -- power and the axle hole applied force by a ** pressure gas bearing are balanced, and you may make it support Thus, by arranging an electromagnet and an iris diaphragm only at one of the two, axle hole composition becomes still compacter.

[0014] The ** pressure magnetism compound axle hole spindle equipment of this invention is supported for the principal axis which has said rotor including the ** pressure magnetism compound axle hole of the composition of above either of this invention, enabling free rotation. Since according to this composition big static stiffness and the outstanding dynamic stability are acquired, and a principal axis can be shortened, a principal axis bends and character frequency is raised, utilization becomes possible as general-purpose spindle equipment for high-speed processing machines. the spindle equipment of this composition -- it may be and the ** pressure magnetism compound axle hole which turns into radial bearing at the load side tip part of a principal axis may be arranged. Thereby, axle hole applied force can be made to act on the RAJIARU load transmitted at the tip of a principal axis effectively to load. To static load, high rigidity can be acquired in particular by making control of a magnetic bearing into an integral action or a proportionality integral action, for example.

[0015] In said each ** pressure magnetism compound axle hole of this invention, a

displacement measurement means to measure displacement of a rotor is used as the pressure sensor which measures the pressure of the axle hole side of a ** pressure gas bearing, asks for displacement of a rotor using the measured value of this pressure sensor, and may be made to perform magnetism control of a magnetic bearing. Thus, by carrying out direct measurement of the pressure of a ** pressure gas bearing side, converting this into rotor displacement, and using for control of an axle hole, there is no malfunction of the sensor by the magnetic property unevenness of the rotor sensor target side which poses a problem by the sensor of other methods, and highly precise sensing becomes possible. For example, while the displacement detection below a submicron with highly precise resolution is attained, a small thing can be used for a sensor, a sensor can be stored inside an axle hole, and compact axle hole composition is attained. Moreover, since the axle hole center of a ** pressure gas bearing can be set up by converting the pressure of a ** pressure gas bearing into rotor displacement focusing on a magnetic bearing, it becomes easy to prevent the mutual interference of both bearings. When a semiconductor pressure sensor is used for said pressure sensor, miniaturization of a pressure measurement part can be attained.

[0016] When it is considered as radial bearing, the pressure difference of the ** pressure in the ** pressure gas bearing side which counters the both sides of the diameter direction of a rotor is measured with said pressure sensor, and you may make it calculate displacement of a rotor from this measured value in the ** pressure magnetism compound axle hole of this invention. Thus, by arranging a pressure sensor, it can ask for displacement of a rotor with sufficient accuracy with the small number of pressure sensors.

[0017] When it is considered as an AKISHARU axle hole, the pressure of three or more places on the same circumference of a ** pressure gas bearing side is measured with said pressure sensor, and you may make it calculate displacement of the direction of AKISHARU of a rotor from these pressure measured value in the ** pressure magnetism compound axle hole of this invention. Thus, by setting up a pressure measurement part, it is the small sensor number, therefore displacement of the direction of AKISHARU of a rotor can be measured with sufficient accuracy at low cost.

[0018] Instead of carrying out pressure measurement as mentioned above at three places, the pressure of two places which counters in the diameter direction on the same circumference of a ** pressure gas bearing side is measured with said pressure sensor, and you may make it calculate displacement of the direction of AKISHARU of a rotor from these measured value. Displacement of the direction of AKISHARU of a rotor can be measured more with sufficient accuracy at low cost by the thereby more small sensor number.

[0019] In the ** pressure magnetism compound axle hole of this invention, when it is considered as an AKISHARU axle hole, you may arrange an iris diaphragm of the electromagnet of a magnetic bearing and a ** pressure gas bearing on direction both sides of

an axis of a rotor. In this case, the pressure of the part in which while counters and which is in point symmetry to the rotor center of the arbitrary part of a ** pressure gas bearing side and said arbitrary part in the ** pressure gas bearing side of another side through a rotor is measured with said pressure sensor, and you may make it calculate displacement of the direction of AKISHARU of a rotor from both measured value. Thus, by defining a pressure measurement part, it is the still smaller sensor number, therefore displacement of the direction of AKISHARU of a rotor can be further measured with sufficient accuracy at low cost.

[0020] You may arrange in the ** pressure magnetism compound axle hole of each [these] composition, without separating said pressure sensor from the pressure measurement part of a ** pressure gas bearing side. That is, you may fix a pressure sensor to the pressure measurement part of a ** pressure gas bearing side, or its neighborhood directly. Thereby, desired measuring plane pressure can be measured directly.

[0021] Moreover, in the ** pressure magnetism compound axle hole of each [these] composition, instead of arranging a pressure sensor to a measuring plane, a pressure sensor may be separated from a ** pressure gas bearing side, and may be arranged, and a ** pressure gas bearing side may be connected with a pressure sensor in both a detailed hole, a pipe or these detailed holes, and a pipe. In this composition, said detailed hole is prepared in a ** pressure gas bearing side, and is taken as a hole 1mm or less in diameter. Said pipe is connected and used for said detailed hole, and an inside diameter makes it a thing of 1mm or less. A pressure sensor is attached at the tip of this pipe. Thus, it is effective, if a detailed hole or a pipe is used when a ** pressure gas bearing side or the ** pressure magnetism compound axle hole itself is small and it cannot store a pressure sensor, or when it is vacant in the spindle equipment using this axle hole and there is a space. Moreover, measurement of pressure is attained by making into the inside diameter of 1mm or less the diameter of a pipe which lessens influence on a ** pressure gas bearing, and is connected to it by the detailed aperture of the ** pressure gas bearing side established in pressure measurement being 1mm or less in diameter, without reducing a frequency characteristic.

[0022] In the ** pressure magnetism compound axle hole of each of said composition of this invention, you may use pure material for the core of the electromagnet of a magnetic bearing. If pure material is used, as compared with the core of the magnetic bearing which consisted of lamination steel plates usually used, it is easy to process an iris diaphragm of self-****** etc., and an accurate ** pressure gas bearing can be constituted.

[0023] Instead of making the whole into pure material, the core of an electromagnet constitutes a part from pure material, prepares said iris diaphragm of a ** pressure gas bearing in the portion of this pure material, and is good also considering the portion of others of said core as a lamination silicon steel plate. While this reduces **** generated with the core of an electromagnet, an iris diaphragm of self-****** of a ** pressure gas bearing etc. can be formed

easily.

[0024] In the ** pressure magnetism compound axle hole of each of said composition of this invention, a lamination silicon steel plate may be used for said rotor, and the coating layer of Ceramics Sub-Division below 1mm thickness may be given on this lamination silicon steel plate. With constituting a rotor from a lamination silicon steel plate, **** at the time of a high velocity revolution can be reduced, and generation of heat of the rotor at the time of a high velocity revolution can be suppressed. Furthermore, also when between an axle hole side and a rotor contacts by coating the outer diameter with ceramic material, damage to a rotor can be minimized. By making a coating layer into Ceramics Sub-Division, **** by the magnetic flux from the electromagnet of a magnetic bearing is not generated, and it can apply to a high velocity revolution. Furthermore, the peripheral face of a coating layer can turn into a rotor side of a ** pressure gas bearing, inner skin turns into a rotor side of a magnetic bearing, and the optimal axle hole crevice between ** pressure gas bearings and the axle hole crevice between magnetic bearings can be set up by adjusting the thickness of a coating layer.

[0025] The pure material of soft magnetism may be used for said rotor by low thermal expansion nature, and the coating layer of Ceramics Sub-Division below 1mm thickness may be given on this pure material. When preparing a rotor in a principal axis, it is desirable to also make the principal axis into the pure material of the same material as a rotor. In bar material can be used for pure material, for example. Thus, by using pure material for a rotor, a rotor bends, character frequency can raise and it becomes possible to depend and to rotate to a high speed. Furthermore, also when a rotor generates heat, by low thermal expansion nature, change of an axle hole crevice is small and the stable ** pressure gas bearing performance can be secured. Moreover, since there are also few amounts of expansion to the direction of an axis, when it uses for the principal axis for machine tools, an effect is in improvement in processing accuracy.

[0026] The magnetic bearing control means which carries out feedback control of the magnetic bearing according to the measured value of a displacement measurement means to measure displacement of a rotor, in the ** pressure magnetism compound axle hole of each of said composition of this invention is established. This magnetic bearing control means is good also as what does not control only by the integral action or a proportionality integral action, and does not control to the high frequency more than predetermined. Thus, only an integral action or a proportionality integral action is performed, without spoiling the dynamic stability which excelled [control / to the high frequency more than predetermined] in the ** pressure gas bearing, a magnetic bearing can be limited to the axle hole applied force of only the number region of low frequency waves, and improvement in the static stiffness which is the feature of it is attained. That is, a ** pressure gas bearing can share dynamic stiffness (high frequency field), and a magnetic bearing can share static stiffness (low frequency wave field),

respectively, and it will take charge, and both the features of both bearings are employed efficiently, and it can avoid interfering mutually.

[0027] when such a magnetic bearing control means is established, without it sends bias current through the coil of the electromagnet of a magnetic bearing by establishing a linearization circuit in the amplifier part which processes the output of said displacement measurement means -- Control voltage - electromagnetism -- it is good also as composition which linearizes the power characteristic. Control voltage - electromagnetism -- linearization of the power characteristic is performed by establishing the square of current feedback circuit in said amplifier part, for example. Thus, by linearizing without sending bias current, negative rigidity peculiar to a magnetic bearing does not occur.

[0028] Moreover, an insensible belt is formed in a means to process the measured value of a displacement measurement means, and a magnetic bearing control means is good also as what does not control a magnetic bearing, when it is in the range of predetermined displacement. A means to form an insensible belt may be prepared in the preceding paragraph apart from a magnetic bearing control means, or may be prepared in a magnetic bearing control means. When it shifted slightly [since adjustment of a sensor of the center of a magnetic bearing and the center of a ** pressure gas bearing is poor], or when the drift by temperature etc. occurs in a displacement sensor, even if there is a rotor at the center of a ** pressure gas bearing, current flows into the coil of a magnetic bearing and it becomes the disturbance to a ** pressure gas bearing. The aforementioned insensible belt can prevent this, and can prevent the interference to a ** pressure gas bearing from a magnetic bearing, and the stable ** pressure magnetism compound axle hole can be constituted.

[0029] [the principal axis which has said rotor / in the case of the ** pressure magnetism compound axle hole spindle equipment supported free / rotation] including the ** pressure magnetism compound axle hole of one of the aforementioned composition After operating a ** pressure gas bearing and carrying out non-contact surfacing of the principal axis at the time of starting of a **** magnetism compound axle hole, the direct-current ingredient of the output of the displacement detection means at that time may be adjusted to zero, and a control means to operate the function of a magnetic bearing may be established after that. This control means may be made to make it serve a double purpose with a magnetic bearing control means, or may be established independently. thus -- being able to amend the temperature drift of the sensor used as the displacement detection means by spindle environment etc., and being based on a sensor output by making it start, -- electromagnetism -- the malfunction of the magnetic bearing which generates power is avoidable.

[0030] [moreover, in the case of the ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor including the ** pressure magnetism compound axle hole of one of the aforementioned composition enabling free

rotation] After operating a ** pressure gas bearing and carrying out non-contact surfacing of the principal axis at the time of starting of a **** magnetism compound axle hole, a principal axis may be rotated, the direct-current ingredient of the output of a displacement detection means may be adjusted to zero in the state where it became more than predetermined number of rotations or it, and a control means to make it operate the function of a magnetic bearing may be established after that. This control means may be made to make it serve a double purpose with a magnetic bearing control means, or may be established independently. The number of rotations of a rotor is obtained from the rotation sensor formed suitably. Since the pressure and pressure distribution in a ** pressure gas bearing crevice will be changed if the high velocity revolution of the spindle is carried out, the zero point of a pressure sensor may move slightly at number of rotations. In such a case, when a magnetic bearing is always operated, a gap will arise in a large rotation field and the direct-current current for correcting this gap will flow into an electromagnet through the magnetic bearing center and ** pressure gas bearing center which were set up beforehand. By the magnetic flux generated at this time, within a rotor, **** arises and it becomes difficult for increase and generation of heat of brake torque to take place, and to carry out the high velocity revolution of the rotor. What is necessary is just to aim at improvement in the static stiffness by a magnetic bearing on the usual operating condition above the time of rated rotation, or predetermined number of rotations. Then, in a setting number-of-rotations region, improvement in the speed of a rotor is realizable in operating a magnetic bearing, only when the principal-axis rotation center at the time of operating only a ** pressure gas bearing is set as the zero point of a sensor and this number-of-rotations region is arrived at. Therefore, improvement in the speed of spindle equipment equipped with this axle hole can also be attained.

[0031] Furthermore, it detects that the principal axis became including the ** pressure magnetism compound axle hole of one of the aforementioned composition more than predetermined number of rotations in the case of the ** pressure magnetism compound axle hole spindle equipment supported for the principal axis which has said rotor enabling free rotation. You may make it operate a band ERIMINETO filter as a magnetic bearing control means. This composition is applicable also in the spindle equipment which established the control means at the time of the aforementioned starting. Thus, above predetermined number of rotations, by inserting in the control system of a magnetic bearing the band ERIMINETO filtering function which was in agreement with principal-axis number of rotations, the principal-axis rotation synchronous ingredient used as the main ingredients of a displacement detection means can be removed alternatively, and operation of a magnetic bearing can be limited only to a low frequency wave. Power consumption can be reduced by controlling control of a high frequency field unnecessary for a magnetic bearing.

[0032] [furthermore, in the case of the ** pressure magnetism compound axle hole spindle

equipment supported for the principal axis which has said rotor including the ** pressure magnetism compound axle hole of one of the aforementioned composition enabling free rotation] The control gain of the magnetic bearing is lowered at the time of low-speed rotation, and when a principal axis becomes more than predetermined number of rotations, you may make it change said control gain to a predetermined value. A setup and change of this control gain are made, for example with said magnetic bearing control means. Thus, since a magnetic bearing is operated where a gain is lowered, the principal axis of the moment of operating a magnetic bearing, and the disturbance to a rotor can be controlled. The composition which makes a setup and change of this control gain is also applicable to the spindle equipment of each of said composition.

[0033]

[Mode for carrying out the invention] The 1st embodiment of this invention is explained with drawing 1 or drawing 3 . Drawing 1 shows the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning this embodiment. A pair of ** pressure magnetism compound axle holes 3 and 3 arranged before and after a motor 5 in the cylindrical housing 2 which this ** pressure magnetism compound axle hole spindle equipment 1 is spindle equipment of the built-in motor form of a machine tool, and serves as a spindle stand, A principal axis 4 is supported free [rotation] through the thrust magnetic bearing 10 of the back end. A principal axis 4 serves as a rotor of the ** pressure magnetism compound axle hole 3. A motor 5 consists of a motor part rotor 6 prepared in the principal axis 4 at one, and a stator 7 directly installed in housing 2. Flanges 21A and 21B are formed in a housing 2 order end, and inner skin of these flanges 21A and 21B is made into the axle hole side 22 for protection which consists of a material excellent in lubricity. Even when abnormalities arise in the compound axle hole 3 and a principal axis 4 touches down by this, printing of a principal axis 4 is prevented. The thrust magnetic bearing 10 consists of an axle hole rotor 19 prepared in the principal axis 4 at one, and a pair of axle hole stators 20A and 20B which are installed in housing 2 and sandwich the above-mentioned axle hole rotor 19 in the direction of an axis from order. The coil current of the axle hole stators 20A and 20B is controlled by the measured value of the thrust displacement sensor 24 which detects the direction displacement of an axis of a principal axis 4. The thrust displacement sensor 24 is formed in the rear wall 23 of housing 2.

[0034] The ** pressure magnetism compound axle holes 3 and 3 of order are made to unify as follows, so that a combination portion may produce the RAJIARU magnetic bearing 8 and the RAJIARU ** pressure gas bearing 9 in component parts. The ** pressure air bearing is used for the **** gas bearing 9. In addition, the ** pressure air bearing is used for each ** pressure gas bearing also in each below-mentioned embodiment. The RAJIARU magnetic bearing 8 consists of an axle hole rotor 11 of the magnetic body prepared in the perimeter of the principal

axis 4, and an axle hole stator 12 installed in housing 2. The axle hole stator 12 is formed in the shape of a ring by the core 13, the coil 14, and the coil cover material 18. The large soft magnetism pure material of peculiar resistance is used for a core 13. A core 13 makes two or more York parts 13a project from a ring-like portion radiately mutually to the inside diameter side, as shown in drawing 2 , and said coil 14 is wound around each York part 13a. The core cover material 18 which consists of a partition which consists of the restoration by thermal spraying which consists of a resin mold, non-magnetic metal material, or ceramic material, non-magnetic metal material, or SERAKKUSU material is filled up with the crevice between the ****** York part 13a and 13a. With the tip side of the York part 13a, the same cylinder side is made to the inside diameter side of the core cover material 18, and it is processed. The inside diameter side of the shape of a cylinder side of the axle hole stator 12 consists of these core cover material 18 and a York part 13a.

[0035] the iris diaphragm 15 which the air supply passage 16 covering all the circumferences is formed in the inside of the ring-like part of the axle hole stator core 13, branches respectively from this air supply passage 16, and supplies air to an axle hole crevice -- the electromagnetism of each York part 13a -- an opening is carried out to the tip inside diameter side which is a power generating side, and it is prepared in it. The air supply passage 16 is connected to the source of supply (not shown) of the compressed air which is pressure fluid for piping etc. from the air supply opening 17 prepared in one place of the direction of a circumference, or two or more places, and the supplied compressed air blows off in the axle hole crevice d formed between the inside diameter side of the axle hole stator 12, and a principal axis 4. The RAJIARU ** pressure gas bearing 9 consists of these iris diaphragms 15, and the axle hole stator core 13 and the core cover material 18 which make an axle hole crevice formation member serve a double purpose. Moreover, the axle hole stator core 13 makes the formation member of iris diaphragm 15 and the air supply passage 16 serve a double purpose. The ** pressure gas bearing 9 will be arranged in the direction width of an axis of the whole magnetic bearing 8 by this composition. Moreover, since the gap of the magnetic bearing 8 serves as a crevice between the axle hole stator core 13 and a principal axis 4, the axle hole crevice d between the ** pressure gas bearings 9 and the gap of the magnetic bearing 8 will be mutually prepared in the same position of the direction of an axis of a principal axis 4. As shown in drawing 3 , iris diaphragm 15 is self-****** and consists of the air supply holes 15a and the axle hole crevices d which were established in the core 13. The portion to which an inside diameter carries out the opening of the air supply hole 15a to the ** pressure gas bearing side which is formed with the stage and consists of an inside of a core 13 serves as a detailed hole, and a part for this detailed pore is 1mm or less in diameter. Thus, when self-****** is used for the air supply form of a ** pressure gas bearing, the stability over a NYUMA tick hammer can improve and it can raise, the axial stability, i.e., dynamic stiffness, of

a high frequency region. As for iris diaphragm 15, it is desirable to arrange to at least three places of the direction of the circumference of a principal axis 4.

[0036] In addition, although the whole York part 13a was made into pure material, as shown in drawing 4 , only circumference [iris diaphragm] part 13aa of the York part 13a is formed by pure material, and part 13ab near un-[iris diaphragm] which is the portion of others of the York part 13a is good in this embodiment, also as a lamination silicon steel plate. In any case, since the portion of self-****** 15 formed by a detailed hole is manufactured by pure material, compared with the case where it is processed into the core which consisted of lamination steel plates usually used, such a detailed hole can be formed easily and a ** pressure gas bearing can be formed with sufficient accuracy. Moreover, like the example of drawing 4 , when [all] a lamination silicon steel plate is used in addition to circumference [iris diaphragm] part 13aa, **** generated with a core 13 compared with the case where it is considered as pure material can be reduced.

[0037] Since this ** pressure magnetism compound axle hole 3 combines the ** pressure gas bearing 9 and the magnetic bearing 8 in this way, it is made with the dynamic stiffness and rotation accuracy which were excellent in the ** pressure gas bearing 9, and the axle hole which employed the feature of both who are called the static stiffness which was excellent in the magnetic bearing 8 efficiently. and -- compared with the case where the ** pressure gas bearing 9 and the magnetic bearing 8 only arrange a ** pressure gas bearing and a magnetic bearing side by side in the direction of an axis since component parts are made to serve a double purpose, composition becomes compact -- length shortening of a principal axis 4 -- it can do. By this, it bends, character frequency is raised, and a high velocity revolution becomes more possible. In order for the axle hole stator core 13 and the core cover material 18 of the magnetic bearing 8 to make the axle hole crevice formation member of the ** pressure gas bearing 9 serve a double purpose, and for said axle hole stator core 13 to extract and to make the formation member of 15 and the air supply passage 16 serve a double purpose by this embodiment especially, Component parts are combination-ized highly and the effect of miniaturization of composition is high.

[0038] The control system of said ** pressure magnetism compound axle hole 3 is explained. The vent 26 for pressure sensing which penetrates the core cover material 18 in the axle hole stator 12 radially, and carries out an opening to the axle hole crevice d is formed in the four directions of a circumference near the iris diaphragm 15 at equal intervals, and the pressure sensors 27A-27D are formed in the sensor wearing hole 25 which is open for free passage to this. Two sensors which counter in the diameter direction mutually become 1 set, and let these pressure sensors 27A-27D be the differential pressure-type air micro sensors which detects RAJIARU displacement of a principal axis 4. Namely, in the pressure sensors 27A and 27B which counter in the diameter direction mutually, the pressure sensors 27C and 27D other one

group for one group between the groups of one [nothing and] pressure sensors 27A and 27B The corresponding vent 26 measures the pressure difference in the ** pressure gas bearing side which carries out an opening, and converts this into displacement of the direction of the Y-axis of a principal axis 4. Moreover, also between the groups of the pressure sensors 27C and 27D of another side, the corresponding vent 26 measures the pressure difference in the ** pressure gas bearing side which carries out an opening, and converts this into displacement of the direction of the X-axis of a principal axis 4.

[0039] [the magnetic bearing control means 28 which consists of a controller 28a, amplifier 29, etc.] It has the feedback control system of the direction of the Y-axis, and the direction of the X-axis, and feedback control of the direction of the Y-axis of the magnetic bearing 8 is performed in the feedback control system of the direction of the Y-axis based on the displacement to the direction of the Y-axis of the principal axis 4 detected by the above-mentioned pressure sensors 27A and 27B. That is, according to displacement of a principal axis 4, the current supplied to the coil 14 of the position corresponding to the pressure sensors 27A and 27B or some coils 14 of the neighborhood through amplifier 29 is adjusted, and it controls so that a principal axis 4 does not incline in the direction of the Y-axis. That is, it controls so that a principal axis 4 is in agreement with a target position. The feedback control system of the direction of the X-axis of the magnetic bearing control means 28 performs current control of the predetermined coil 14 by the measured value of other pressure sensors 27C and 27D like this. Thus, in order to adopt the air micro sensor method using the pressure sensors 27A-27D which detect the ** pressure of the axle hole crevice d as a displacement sensor of the magnetic bearing 8, The zero point (desired value) of a control system of the magnetic bearing 8 and the support central point (pressure balance point) of the ** pressure gas bearing 9 can be coincided easily, and complicated sensor adjustment becomes unnecessary. Moreover, the magnetic property unevenness and the deviation-from-circular-form error of a rotor sensor target side which pose a problem by the sensor of other methods become unrelated.

[0040] Feedback control by the magnetic bearing control means 28 is made only into an integral action or a proportionality integral action, and compensation in high frequency is not performed. Moreover, when the zero point of a magnetic bearing control system and the support central point of the ** pressure gas bearing 9 shift by the drift of the pressure sensors 27A and 27B etc., in integral control, you may form few insensible belts w (drawing 5). Even if it sets up the insensible belt w by forming the insensible belt circuit 31 like drawing 6 between the pressure sensors 27A and 27B and the magnetic bearing control means 28, you may set it up by preparing an insensible belt circuit in the control circuit which constitutes the magnetic bearing control means 28. Thus, by forming the insensible belt w, the malfunction of the magnetic bearing 8 by a temperature drift etc. can be controlled. That is, the ** pressure gas

bearing 9 can share dynamic stiffness (high frequency field), the magnetic bearing 8 shares static stiffness (low frequency wave field), respectively, the role assignment to take charge of can be ensured, both the features of both bearings 8 and 9 are employed efficiently, and it can avoid interfering mutually. Moreover, in this way, since the magnetic bearing 8 serves as a low frequency wave control system called an integral action or a proportionality integral action, it can use the pressure sensors 27A-27D with a comparatively late response as a displacement sensor. Although the performance of the magnetic bearing 8 can be set up by setup of the magnetic bearing control means 28, generally, in the case of a magnetic bearing, damping force is generated effective in a high frequency region, and there is a problem that it is difficult to be stabilized and to surface a principal axis. Then, he is trying to use the magnetic bearing 8 only for the duty which raises the axle hole rigidity in the low frequency wave region which is that feature in this invention.

[0041] the amplifier 29 which supplies current to the coil 14 of the magnetic bearing 8 -- Current - electromagnetism -- what has the line type-ized circuit for making power a line type-izing, for example, the square of current feedback circuit, is used. It can linearize by this, without sending bias current, and negative rigidity peculiar to a magnetic bearing is not generated, either. That is, it can avoid that negative rigidity occurs in the magnetic bearing 8, and can prevent that the stability of the ** pressure gas bearing 9 is spoiled by the negative rigidity. Moreover, when a principal axis 4 rotates, **** in the principal axis 4 generated by the bias current can be lost, and a high velocity revolution becomes possible. You may insert in the magnetic bearing control means 28 the band ERIMINETO filter 32 (drawing 7) which synchronized with the number of rotations of the principal axis 4. as opposed to the deflection according to the rotor unbalance at the time of rotation of a principal axis 4 by this -- the electromagnetism from the electromagnet of the magnetic bearing 8 -- it is it weak acting As mentioned above, when the magnetic bearing control means 28 is constituted from an integral action, the applied force of the magnetic bearing 8 in a high frequency region works as unstable power to a principal axis 4. At the time of rotation of a principal axis 4, as for the deflection of a principal axis 4, a rotation synchronous ingredient turns into the main ingredients. It becomes possible to be stabilized and to rotate a principal axis 4 by removing this alternatively.

[0042] In addition, although the pressure sensors 27A-27D detected displacement of the principal axis 4 directly in this embodiment It converts from the measured value by a pressure sensor, asks for the size of the crevice between a principal axis 4 and a ** pressure gas bearing side, and may be made to perform control by the magnetic bearing control means 28 according to change of this crevice. Moreover, instead of arranging a pressure sensor inside the core 13 of the magnetic bearing 8 as mentioned above, a hollow pipe (not shown) is arranged so that it may be open for free passage in the axle hole crevice between the **

pressure gas bearings 9, and you may make it measure pressure with an external pressure sensor. Axle hole size is small, and when there is a space which stores a pressure sensor outside, the composition arranged to this exterior is desirable. Furthermore, the pressure sensor 27 is directly arranged in the inside diameter part of the magnetic bearing 8, for example, the portion of core cover material 18 grade, the pressure between a principal axis 4 and a core 13 is measured, and you may make it convert into displacement of a principal axis 4, as shown in drawing 8 .

[0043] Drawing 9 and drawing 10 show the ** pressure magnetism compound axle hole concerning other embodiments. In the ** pressure magnetism compound axle hole 3A in which this example formed the iris diaphragm 15 which supplies air to the axle hole crevice d between the ** pressure gas bearings 9A in the core 13A of the axle hole stator 12 of the RAJIARU magnetic bearing 8A It is the structure which made the core 13A of the electromagnet of the RAJIARU magnetic bearing 8 what is called horseshoe shape, and has arranged the pair of the magnetic pole 13Aa and 13Aa side by side in the direction of an axis of a principal axis 4. Polarity on the same circumference of each magnetic pole 13Aa is made the same. **** generated with a principal axis 4 with rotation of a principal axis 4 by making it this appearance can be decreased. Other composition and an effect are the same as that of the 1st embodiment. If the number of Core 13A puts in another way, as for the number of an electromagnet, it is desirable to consider it as three or more pieces in the direction of the circumference. [thus, the thing for which it shall have three or more electromagnets which constitute the magnetic bearing 8A, magnetic pole 13Aa of the core 13A of each electromagnet is arranged in the direction of the axis of rotation, and the polarity of each magnetic pole 13Aa on the same circumference is coincided] Hysteresis loss and eddy current loss which are generated in the principal-axis part of the magnetic bearing 8A are mitigable with rotation of a principal axis 4. Moreover, since generation of heat of the principal axis 4 by these losses can be controlled, reduction of the thermal expansion **** axle hole crevice between principal axes 4 can be suppressed to the minimum, and the performance of the stable ** pressure gas bearing 9A can be obtained.

[0044] The axle hole 3B of drawing 11 - drawing 13 improves the core form of the RAJIARU magnetic bearing 8A to the example of drawing 9 and drawing 10 . One York part 13Ba side is communalized with the York part which adjoins each other in the direction of the circumference among York part 13Ba of the core 13B arranged in the direction of an axis of a principal axis 4, and 13Bb, and form is made to simplify. Thus, while being able to decrease the processing man day of York 13B of an electromagnet and being able to raise processability with constituting an electromagnet, **** in the magnetic bearing principal-axis portion generated with rotation of a principal axis 4 can be reduced further, and it can respond to a high velocity revolution more.

[0045] Drawing 14 gives the coating layer 33 of Ceramics Sub-Division to an axle hole 3 and the surface of the principal axis 4 which counters in the 1st embodiment. Thereby, printing of the principal axis 4 at the time of touchdown and an axle hole side can be prevented. furthermore, the time of being during operation of the magnetic bearing 8 and a principal axis 4 rotating, since the coating layer 33 is Ceramics Sub-Division -- iron inside the principal axis 4 -- disadvantage generating can be controlled and it can respond to the high velocity revolution of a principal axis 4. Moreover, since the peripheral face of the coating layer 33 turns into a rotor side of the ** pressure gas bearing 9, inner skin turns into a rotor side of the magnetic bearing 8 and it becomes the size which differs in a ** pressure gas bearing crevice and a magnetic bearing crevice, it is adjusting the thickness of the coating layer 33, and the crevice between the optimal ** pressure gas bearing 9 and the magnetic bearing 8 can be set up. if it restricts that magnetic bearing crevice d' becomes large because below 1mm thickness carries out thickness of this coating layer 33, without it will increase the supply current of a coil 14 -- desired electromagnetism -- power can be generated. Moreover, a lamination silicon steel plate (not shown) may be used for the rotor part in the magnetic bearing 8 of a principal axis 4, and the ceramic coating layer 33 may be given on it. The rotor part which consists of said lamination silicon steel plate is prepared, for example in the perimeter of a principal axis 4. In that case, by having used the lamination silicon steel plate, **** at the time of a high velocity revolution can be reduced further, and generation of heat of the rotor at the time of a high velocity revolution can be suppressed. Moreover, it is desirable to use low thermal expansion soft magnetism material, for example, in bar material, for the quality of the material of a principal axis 4 or the quality of the material of a rotor part prepared in the perimeter as mentioned above, and to give the coating layer 33 of Ceramics Sub-Division on the peripheral face. By this, a principal axis 4 or a rotor bends, character frequency is raised, and it becomes possible to rotate to a high speed more. Moreover, since in bar material has a low thermal expansion coefficient, even if a rise in heat is in a principal axis 4, the amount of reduction of axle hole crevice d' by the thermal expansion of a principal axis 4 has the magnetic property which could stop small and was suitable for the magnetic bearing 8. For this reason, the stable ** pressure gas bearing performance is securable. And since there are also few amounts of expansion to the direction of an axis, when it applies to the spindle equipment for machine tools, an effect is in improvement in processing accuracy. Furthermore, when the ceramic coating layer 33 is given from having a low thermal expansion coefficient on the principal axis 4 manufactured, for example by the stainless steel of a ferrite system, generally Ceramics Sub-Division [with the difference of the thermal expansion coefficient of a principal axis 4] Although a crack may occur in the ceramic coating layer 33 or it may separate and produce in it, such a problem is solved by using in bar material.

[0046] In addition, although it extracted to the axle hole stator core 13 and 15 was prepared in

the embodiment of each of said ** pressure magnetism compound radial bearing, iris diaphragm 15 may avoid a core 13 and may form it in coil cover material 18 grade. Moreover, although parts were made to use also [gas bearing / 9 / the magnetic bearing 8 and / ** pressure] in the embodiment of each above-mentioned ** pressure magnetism compound radial bearing A magnetic bearing and the ** pressure gas bearing do not need to make parts not necessarily make it serve a double purpose, and may prepare a ** pressure gas bearing in the direction width of an axis of the whole magnetic bearing, or may prepare a magnetic bearing in the direction width of an axis of the whole ** pressure gas bearing. or the axle hole crevice d between ** pressure gas bearings, the axis of a magnetic bearing, and the gap between stator cores -- mutual -- the abbreviation for the direction of an axis -- what is necessary is just to prepare in the same position Composition which gives a common portion to the width of a magnetic bearing and an electrostatic axle hole is realized by changing arrangement of the parts which constitute a magnetic bearing, and the parts which constitute an electrostatic axle hole in the direction of the circumference etc., without making parts serve a double purpose.

[0047] Drawing 15 shows the example which applied this ** pressure magnetism compound axle hole to the AKISHARU axle hole. the collar of a principal axis 41 with which this ** pressure magnetism compound AKISHARU axle hole equipment consists of a magnetic body -- on both sides of the axle hole rotor 41a which is the thrust supporter of a **, it is constituted from the direction both sides of an axis by two ** pressure magnetism compound AKISHARU axle hole parts 42 and 43. Each ** pressure magnetism compound AKISHARU axle holes 42 and 43 store coils 46 and 47 in the core 44 and 45 of an electromagnet, are extracted into this core 44 and 45, prepare 48, and are prepared in the perimeter of a principal axis 41 in the shape of a ring. Iris diaphragm 48 is self-****** and consists of an air supply hole 48a from which the tip which carries out an opening to the axle hole side of cores 44 and 45 became a detailed hole, and the axle hole crevice d1 and d2. The axle hole stator 52 of the AKISHARU magnetic bearing 49 consists of aforementioned cores 44 and 45 and coils 46 and 47, it extracts as cores 44 and 45 and the AKISHARU ** pressure gas bearing 50 consists of 48.

[0048] Pressure occurs between cores 44 and 45 and Rotor 41a by making this pressure fluid blow off between cores 44 and 45 and Rotor 41a. Moreover, by having formed self-****** 48, by the crevice d1 between cores 44 and 45 and Rotor 41a, and change of d2, pressure and the interval of a crevice change automatically and can form the ** pressure gas bearing which has an automatic alignment function. Thereby, stable surfacing of the rotor 41a can be carried out. In this case, by carrying out minute [of the crevice d1 between cores 44 and 45 and Rotor 41a, and d2] to 0.1mm or less, the axle hole rigidity by this ** pressure gas bearing is raised, and as for Rotor 41a, a ** pressure gas bearing independent is stabilized, and it can rise to surface.

[0049] The displacement sensor 51 which measures the distance between cores 44 and 45 and Rotor 41a is formed outside, and the magnetic bearing control means 53 which carries out feedback control of the current sent through coils 46 and 47 according to the measured value of that displacement sensor 51 is formed in this ** pressure magnetism compound axle hole. The magnetic bearing control means 53 carries out current control, for example through amplifier 54. Thereby, the axle hole composition combining and [** pressure] and a magnetic bearing is attained. The thing of the same function as a magnetic bearing control means 28 by which it explained by the 1st embodiment etc. can be used for this magnetic bearing control means 53.

[0050] Instead of forming said displacement sensor 51 in the ** pressure magnetism compound AKISHARU axle hole equipment of this embodiment The pressure of a **** gas bearing side may be measured, and you may convert and ask for the size of the axle hole crevice d in the ** pressure gas bearing 50, i.e., the core 45 of an electromagnet and the crevice d between Rotors 41a (d1, d2), with this pressure. The current of coils 46 and 47 is controlled by the detection result of the size of this crevice d with the magnetic bearing control means 53. In the case of the displacement measurement by pressure measurement, there is no malfunction of the sensor by the magnetic property unevenness of the rotor sensor target side which poses a problem by the sensor of other methods, and highly precise sensing becomes possible.

[0051] The pressure sensor 55 is arranged inside the cores 44 and 45 of an electromagnet, and you may make it measure the pressure of the ** pressure gas bearing 50 directly in this embodiment, for this pressure measurement, as shown in drawing 16 . The hollow pipe 56 is formed in the form linking directly to the ** pressure gas bearing 50, and you may make it measure pressure with the external pressure sensor 57, as shown in drawing 17 . In this case, the detailed hole 59 for pressure measurement is formed in the composition member of the axle hole side of the ** pressure gas bearings 50, such as a core 44, and the hollow pipe 56 is combined with this detailed hole 59. Axle hole size is small, and when the space of a pressure sensor is outside, it is advantageous to form the pressure sensor 57 outside. Moreover, measurement of pressure is attained by regulating the inside diameter (diameter) of the pipe 56 which lessens influence on a ** pressure gas bearing, and is connected to it by regulating the diameter of said detailed hole 59 prepared in pressure measurement with 1mm or less to 1mm or less, without reducing a frequency characteristic.

[0052] Drawing 18 is the figure having shown the A-A section of drawing 16 . In this example, the pressure of three or more (drawing 18 the three point of measurement a1, a2, a3) pitches, such as the same circumference [in / for a sensor pressure measurement part / the ** pressure gas bearing side of a ** pressure magnetism compound AKISHARU axle hole] top, is measured. The rotor 41a of each part, the crevice d1 between the electromagnet cores 44 and

45, and the value of d2 are converted from each measured value, and the average of the value is taken. Thereby, the direction position of AKISHARU of Rotor 41a can be measured correctly. The operation which takes said average is performed, for example with the magnetic bearing control means 53.

[0053] As shown in drawing 19 , you may be made to carry out by the two point of measurement b1 on the circumference which was left 180 degrees and which counters, and b2 instead of measuring pressure as mentioned above at three places. Drawing 19 is a figure equivalent to the A-A section of drawing 16 . The direction position of AKISHARU of Rotor 41a can be measured with the minimum pressure sensor number, without being influenced by pitching movement or yawing movement of Rotor 41a by setting the pressure point of measurement b1 and b2 in this way to two on the circumference which left 180 degrees.

[0054] When countering the both sides of Rotor 41a like the example of drawing 16 and forming the ** pressure magnetism compound AKISHARU axle hole parts 42 and 43, the axle hole crevice d1 and the point of measurement which measures the pressure of d2 are good also as every one place about each axle hole crevice d1 and d2, as shown in drawing 20 . In that case, you may be two points from which 180 degrees of point of measurement c2 of the axle hole crevice d2 between one of the two has already been separated on the same circumference in the surface of projection with the point of measurement c1 of the axle hole crevice d1 between one of the two. Moreover, the magnetic bearing control means 53 calculates both the point of measurement c1, the axle hole crevice d1 calculated from the pressure measured value of c2, and the difference of d2, and is made to perform current control. Also when thermal expansion is in Rotor 41a further by this, without being influenced by pitching movement or yawing movement of Rotor 41a, the direction position of AKISHARU of Rotor 41a can be measured with the minimum pressure sensor number. By the method explained with these drawing 18 or drawing 20 , displacement of the direction of AKISHARU of Rotor 41a can be correctly measured at low cost.

[0055] In addition, a semiconductor pressure sensor may be used for the pressure sensors 51, 55, and 27 of the example of the pressure sensor shown in said each embodiment, for example, drawing 15 , and drawing 16 , and the example of drawing 8 . Thereby, it is compact in equipment and the measurement result can be directly taken out outside by an electric signal.

[0056] Drawing 21 shows the ** pressure magnetism compound AKISHARU axle hole concerning the embodiment of further others. Let this example be an AKISHARU axle hole only supporting one of the two of the rotor 41a of a principal axis 41. That is, the iris diaphragm 48 of the stator core 45 of the magnetic bearing 49 and the ** pressure gas bearing 50 is arranged only in one side of the direction of an axis of Rotor 41a. In this example, the applied force Fm to the rotor 41a by the magnetic bearing 49 works as power of absorption, and, on

the other hand, the applied force Fs to the rotor 41a by the ** pressure gas bearing 50 acts as restitution. Therefore, a rotor cannot be supported when [which is the ** pressure gas bearing 50] the direction of a rotor axis suits in the perpendicular direction, if independent. However, by decoding with the magnetic bearing 49, an axle hole installs, and it does not depend on a direction, but Rotor 41a can be supported. Thus, the magnetic bearing 49 and the ** pressure gas bearing 50 are arranged only at one of the two of the thrust supporter 41a of a principal axis 41, and axle hole composition becomes still compacter by considering it as the ** pressure magnetism compound axle hole it was made to balance power of absorption and restitution.

[0057] Drawing 22 shows the longitudinal section of the ** pressure magnetism compound axle hole spindle equipment concerning other embodiments. In the ** pressure magnetism compound axle hole spindle equipment 1 of drawing 1 , this ** pressure magnetism compound axle hole spindle equipment 1 changes the arrangement relation between a motor 5 and each axle holes 3, 3, and 10, and arranges the motor 5 at the backmost part in housing 2. The thrust magnetic bearing 10 is arranged among the ** pressure magnetism compound axle holes 3 and 3 of order. Other composition is the same as said embodiment. In motor arrangement of the embodiment of drawing 1 , when a motor 5 is made into high power, the thickness of the rotor 6 of a motor 5 and mass become large, it bends, and character frequency may be reduced, but this can be coped with by arranging a motor 5 in the back end part of a principal axis 4 like the embodiment of drawing 22 .

[0058] Drawing 23 shows the embodiment of further others. In the ** pressure magnetism compound axle hole spindle equipment 1 of drawing 1 , the eddy current-type displacement sensor 30 is used for this ** pressure magnetism compound axle hole spindle equipment 1 as a sensor which detects RAJIARU displacement of the principal axis 4 to an axle hole. Although whichever of order is sufficient as the installation position of the sensor 30 to each ** pressure magnetism compound axle hole 3, in the example of illustration, the thing to the ** pressure magnetism compound axle hole 3 of the front part is made into the axle hole front, and let the thing to the hind ** pressure magnetism compound axle hole 3 be axle hole back. In addition, it may replace with the above-mentioned eddy current type displacement sensor 30, and a reluctance type displacement sensor and an electric capacity type displacement sensor may be used. Other composition is the same as the embodiment of drawing 1 .

[0059] Drawing 24 shows the spindle equipment of further others constituted from a ** pressure magnetism compound axle hole. This spindle equipment consists of 2 sets of ** pressure magnetism compound radial bearings 65 and 66, 1 set of ** pressure magnetism compound AKISHARU axle holes 67, and a motor 69 made to rotate a principal axis 68. the collar with which a principal axis 68 is supported by the ** pressure magnetism compound AKISHARU axle hole 67 -- it has the rotor 41a of a **. You may use which thing explained by